Natural Conditions Assessment for low DO Chickahominy River between Henrico and Hanover Counties, Virginia

Submitted by

Virginia Department of Environmental Quality

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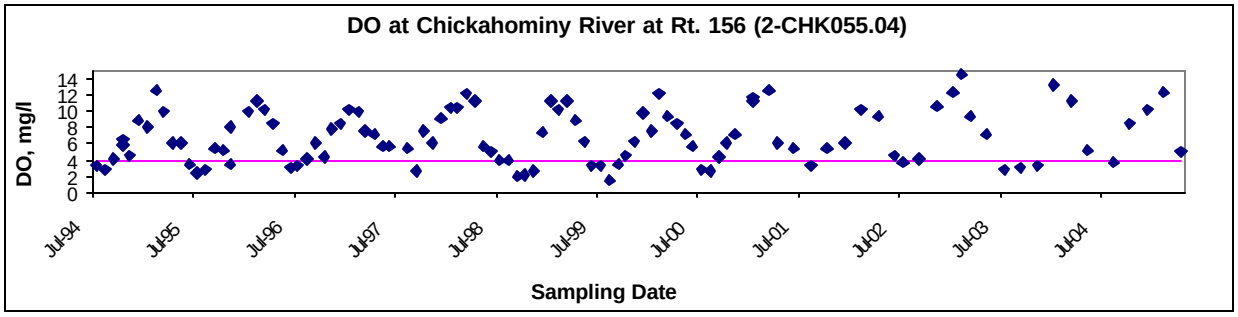
Executive Summary

This report presents the assessment of whether low dissolved oxygen (DO) in the Chickahominy River is due to natural conditions or whether a Total Maximum Daily Load (TMDL) must be performed because of anthropogenic impacts. The Chickahominy River is located in Henrico, Hanover, New Kent, Charles City and James City Counties in the James River Basin (USGS Hydrologic Unit Code 02080206). The waterbody identification code (WBID, Virginia Hydrologic Unit) for non-tidal Chickahominy River is VAP-G06R-01N. There are 676.9 total stream miles and 7.93 tidal square miles in the Chickahominy River watershed (National Hydrography Dataset (NHD). The impaired segment is 10.3 stream miles of Chickahominy River between the Rt. 360 and 156 bridges. The impairment is for low DO.

The drainage area of Chickahominy River and its tributaries is approximately 468.3 square miles. The average annual rainfall is 47.61 inches. The watershed is approximately 300,203.9 acres in size and is predominately forested (55.0 percent). Agriculture encompasses 14.7 percent of the watershed, with 6.9 percent cropland and 7.8 percent pasture/hayland. Residential and industrial areas compose approximately 13.1percent of the land base. The remaining 17.1 percent of the watershed is comprised of 1.4 percent of transitional areas and grasses, and 15.7 percent wetlands and open water.

The Chickahominy River was listed as impaired on Virginia's 1996 303(d) Total Maximum Daily Load Priority List Report, 1998 303(D) Total Maximum Daily Load Priority List and Report, 2002 303(d) Total Maximum Daily Load Priority List and Report and the 2004 305(b) / 303(d) Integrated Report (VADEQ, 1997, 1998, 2002 & 2004) due to violations of the State's water quality standard for dissolved oxygen. A total of 106 DO concentration data points, with 26 water quality standard violations (24.5%), have been taken by DEQ at station 2-CHK055.04 (see Figure E1) from July 19, 1994 through April 22, 2005.

Figure E1. Time series of DO concentrations (station 2-CHK055.04), July 1994 through April 2005.



According to Virginia Water Quality Standards (9 VAC 25-260-10A), "all state waters are designated for the following uses: recreational uses (e.g., swimming and boating); the propagation and growth of a balanced indigenous population of aquatic life, including game fish, which might be reasonably expected to inhabit them; wildlife; and the production of edible and marketable natural resources (e.g., fish and shellfish)."

As indicated above, Chickahominy River must support all designated uses and meet all applicable criteria. If the waterbody exceeds the instantaneous DO water quality standard of 4.0 mg/l in more than 10.5 percent of samples, the waterbody is classified as impaired and natural conditions must be determined or a TMDL must be developed and implemented to bring the waterbody into compliance with the water quality criterion.

VADEQ proposes a methodology for determining whether low DO originates from natural or anthropogenic sources, adapted from "Methodology for Assessing Natural Dissolved Oxygen and pH Impairments: Application to the Appomattox River Watershed, Virginia." (MapTech 2003)

The level of dissolved oxygen in a water body is determined by a balance between oxygen-depleting processes (*e.g.*, decomposition and respiration) and oxygen restoring processes (*e.g.*, aeration and

photosynthesis). Certain natural conditions promote a situation where oxygen-restoring processes are not sufficient to overcome the oxygen- depleting processes. Conditions in a free-flowing stream that would typically be associated with naturally low DO include slow-moving, ripple-less waters where the bacterial decay of organic matter depletes DO at a faster rate than it can be replenished. Indicators of these conditions include low slope, the presence of wetlands, and often low pH due to organic acids (tannins, humic and fulvic substances) produced in the decay process.

These situations can be compounded by anthropogenic activities that contribute excessive nutrients or readily available organic matter to these systems. The general approach to determine if DO and pH impairments in free-flowing streams are due to natural conditions is to assess a series of water quality and hydrologic criteria to determine the likelihood of an anthropogenic source. A logical 4-step process for identifying natural conditions that result in low DO and/or pH levels and for determining the likelihood of anthropogenic impacts that will exacerbate the natural condition is described below. DEQ staff is proposing to use this approach to implement State Water Control Law 9 VAC 25-260-55, Implementation Procedure for Dissolved Oxygen Criteria in Waters Naturally Low in Dissolved Oxygen.

Before implementing this procedure for low DO, all DO data should be screened for flows less than the 7Q10. DO data collected on days when flow was < 7Q10 should be eliminated from the data set and the violation rate recalculated accordingly.

Step 1. Determine slope and appearance (presence of wetlands).
Step 2. Determine nutrient levels and compare with USGS background concentrations.
Step 3. Determine degree of seasonal fluctuation (for DO only).
Step 4. Determine anthropogenic impacts from permitted dischargers and land use.

Two low DO exceedances were removed from the dataset at listing station 2-CHK055.04 because they occurred at flows below 7Q10, which resulted in a 22.6 percent DO violation rate.

The extent of the swampwater segment determined from the upstream boundary of very low slope near Stony Run in Hanover County, downstream to the boundary of low DO observations just below the confluence with Toe Ink Swamp, has a very low slope of 0.05%. Decomposition of the large inputs of decaying vegetation from areas of forested land with swamps and heavy tree canopy throughout the watershed increase oxygen demand and lower DO as they decay. These are not considered anthropogenic impacts.

The Chickahominy River exhibits low nutrient concentrations below national background levels in streams from undeveloped areas, which are not indicative of human impact.

The Chickahominy River exhibits natural seasonal DO fluctuation due to the inverse relationship between water temperature and DO.

A total of 73 facilities are permitted to discharge to the Chickahominy River and its tributaries. The vast majority (70) are either located downstream of the river segment assessed here, or are stormwater permittees without flow or DO permit limits that only discharge during significant rain events. However, three VPDES permittees are located upstream of the proposed swampwater segment, and have design flows and BOD5 or DO permit limits. Tyson Foods Incorporated, VA0004031, with a design flow of 1.4 MGD and maximum BOD5 of 8.0 mg/l, is located on an unnamed tributary of the Chickahominy River 16.1 miles above the upper listing station. Tidewater Quarries Inc. – Springfield Quarry, VA0058041, with a design flow of 0.6 MGD and BOD5 limit of 8.0 mg/l, is located on the Chickahominy River 18.1 miles above the upper listing station. There is a monitoring station at 2-CHK076.59, located between these facilities and the upper listing station, which has only 4.9% low DO violations in 143 visits since 1990. Therefore the Tyson Foods and Tidewater Quarries Inc. discharges are not expected to influence DO at the upper swampy listing station16 to 18 rivermiles downstream. Travel Center of America Inc, VA0061972, with a design flow of 0.01MGD and BOD5 limit of 8.0 mg/l, is located on a UT to Lickinghole Creek 11.8 miles above station 2-CHK062.57. This facility only discharges during significant rainfall events, and with the small design flow is not expected to significantly affect DO at 2-CHK062.57.

Residential and high use industrial areas compose approximately 13.1 percent of the land base, a significant portion of the watershed. However, most of the urban land use occurs in the Upham Brook watershed, which passes through a swampy area of significant size in its lower portion before entering the Chickahominy River. There is a station on Upham Brook, 2-UPM003.53 at Rt. 1, which has zero violations in 101 visits since 1990. The swampy lower segment of Upham Brook below Rt. 1 also has three stations with a combined 5.6% DO violations. This segment also removes significant anthropogenic influences such as nutrients, as shown by the nutrient average concentrations below USGS background levels at station 2-CHK062.57 just below the Upham Brook mouth. The watershed is predominately forested (55.0 percent), with 17.1 percent wetlands and open water. The land use is not considered to have significantly impacted the swampwater conditions of the mainstem Chickahominy River, given the nutrient concentrations below the USGS background levels just below where Upham Brook enters the mainstem.

Based on the above information, a change in the water quality standards classification to Class VII Swampwater due to natural conditions, rather than a TMDL, is indicated for mainstem Chickahominy River from its confluence with Stony Run at rivermile 71.03 downstream to the confluence with Toe Ink Swamp at rivermile 43.07, a total of 28.0 rivermiles. If there is a 305(b)/303(d) assessment prior to the reclassification, Chickahominy River will be assessed as Category 4C, Impaired due to natural condition, no TMDL needed.

DEQ performed the assessment of the Chickahominy River low DO natural condition in lieu of a TMDL. Therefore neither a TMDL Technical Advisory Committee (TAC) meeting nor a public meeting was involved. Public participation will occur during the next water quality standards triennial review process.

1. Introduction

The Chickahominy River was listed as impaired on Virginia's 1996 303(d) Total Maximum Daily Load Priority List Report, 1998 303(D) Total Maximum Daily Load Priority List and Report, 2002 303(d) Total Maximum Daily Load Priority List and Report and the 2004 305(b) / 303(d) Integrated Report (VADEQ, 1997, 1998, 2002 & 2004) due to violations of the State's water quality standard for dissolved oxygen and fecal coliform bacteria. This report evaluates the DO impairment by determining if natural conditions are the cause of the impairment, thus obviating the need for a TMDL. The fecal coliform impairment has been addressed separately from this document.

A glossary of terms used throughout this report is presented as Appendix A.

2. Physical Setting

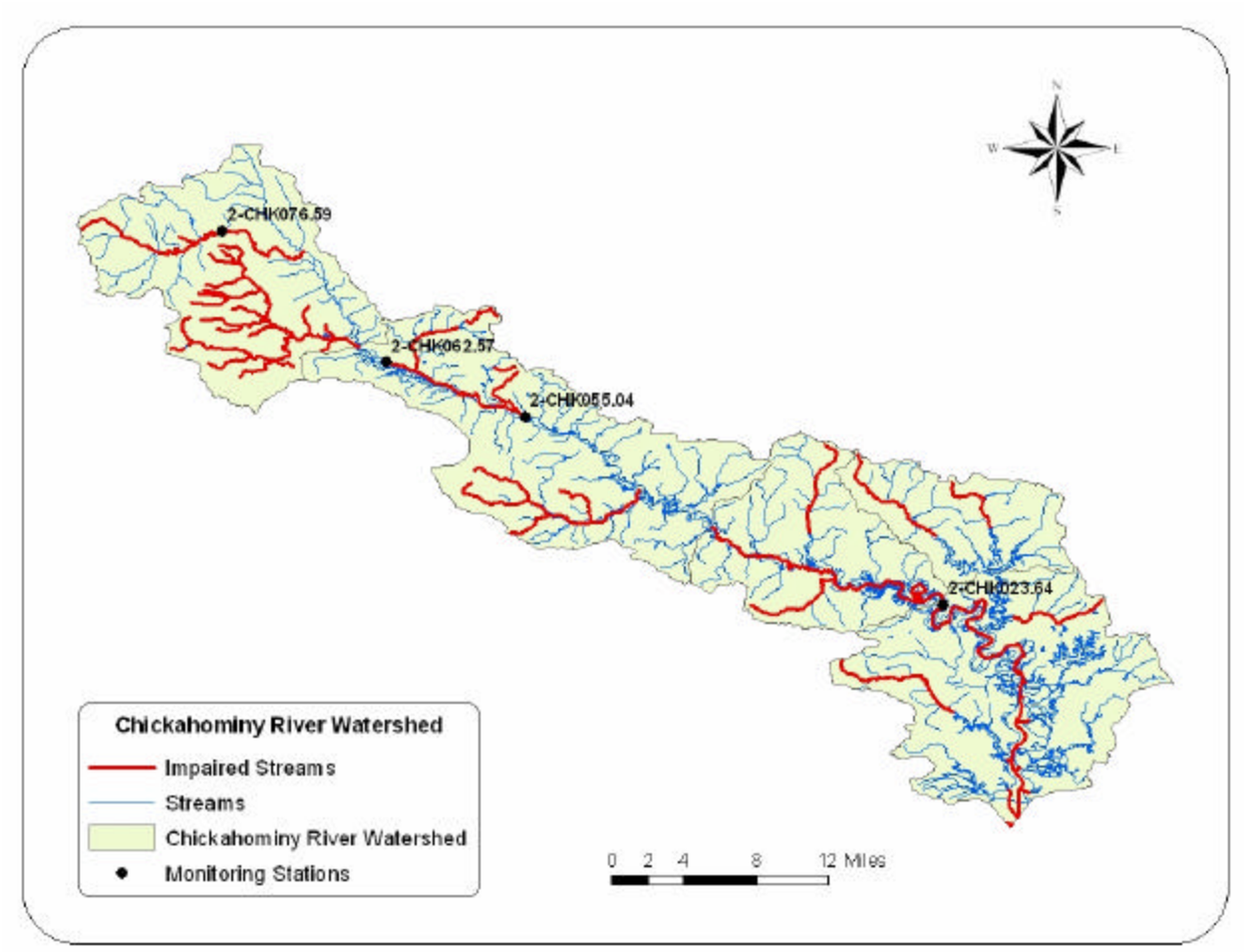
2.1 Listed Water Bodies

Chickahominy River is located in Henrico, Hanover, New Kent, Charles City and James City Counties in the James River Basin (USGS Hydrologic Unit Code 02080206). The waterbody identification code (WBID, Virginia Hydrologic Unit) for non-tidal Chickahominy River is VAP-G06R-01N. There are 676.9 total stream miles and 7.93 tidal square miles in the Chickahominy River watershed (National Hydrography Dataset (NHD). The impaired segment is 10.3 stream miles of Chickahominy River between the Rt. 360 and 156 bridges. This report addresses only the DO impairments, the fecal coliform impairments are reported separately. These segments are described in Table 1 and Figure 1.

Table 1. Impaired segment descriptions (Chickahominy River).

Segment (segment ID)	Impairment (source of impairment)	Upstream Limit Description	Downstream Limit Description	Miles Affected
Chickahominy River VAP-G05R-01N	Dissolved Oxygen (Natural conditions) Fecal coliform	Rt. 360 Bridge	Rt. 156 Bridge	10.3

Figure 1. Map of the Chickahominy River study area.



2.2. Watershed

2.2.1. General Description

The Chickahominy River, located in Henrico, Hanover, New Kent, Charles City, and James City Counties, Virginia, is a major tributary of the James River. The river is approximately 85.9 miles long and flows southeast from its headwaters near Hylas, VA to its confluence with the James River. The watershed has an area of approximately 468.3 square miles. There is a continuous flow gaging station on the Chickahominy River near Providence Forge, VA, 02042500, located 19.8 miles downstream of the lower boundary of the impaired area with a drainage area of 248 mi^2.

2.2.2. Geology, Climate, Land Use

Geology and Soils

The impaired segment of the Chickahominy River is in the Atlantic Coastal Plain physiographic region. The Atlantic Coastal Plain is the easternmost of Virginia's physiographic provinces. The Atlantic Coastal Plain extends from New Jersey to Florida, and includes all of Virginia east of the Fall Line. The Fall Line is the easternmost extent of rocky river rapids, the point at which east-flowing rivers cross from the hard, igneous and metamorphic rocks of the Piedmont to the relatively soft, unconsolidated strata of the Coastal Plain. The Coastal Plain is underlain by layers of Cretaceous and younger clay, sand, and gravel that dip gently eastward. These layers were deposited by rivers carrying sediment from the eroding Appalachian Mountains to the west. As the sea level rose and fell, fossiliferous marine deposits were interlayered with fluvial, estuarine, and beach strata. The youngest deposits of the Coastal Plain are sand, silt and mud presently being deposited in our bays and along our beaches (http://www.geology.state.va.us/DOCS/Geol/coast.html).

Soils for the Chickahominy River watershed were documented utilizing the VA State Soil Geographic Database (STATSGO). Nine general soil types were identified using in this database. Descriptions of these soil series were derived from queries to the USDA Natural Resources Conservation Service (NRCS) Official Soil Series Description web site (http://ortho.ftw.nrcs.usda.gov/cgi-bin/osd/osdname.cgi). Figure 2 shows the location of these general soil types in the watershed.

Soils of the **Emporia-Johnston-Kenansville-Remlik-Rumford-Slage-Suffolk-Tomotley series (VA027)** are very deep, very poorly to somewhat excessively drained, with moderately rapid to slow permeability. They are composed of muck, loam and fine sand, with slopes ranging from 0 to 65 percent.

Soils of the **Appling-Wedowee-Ashlar-Louisburg-Vance-Worsham series (VA030)** are moderate to very deep that formed in residuum from weathered igneous, metamorphic, and crystalline rock of the Piedmont Plateau. Soils range from excessively to poorly drained, with moderately rapid to slow permeability.

Soils of the **State-Turbeville-Hiwassee-Dogue-Augusta-Congaree-Chewacla-Wehadkee-Edgehill series** (**VA033**) are very deep to deep soils. Soils are located on stream terraces in the Piedmont and Upper Atlantic Coastal Plain. This series is formed from recent fluvial sediments. The drainage class is moderately well to very poorly drained, with moderate to poor permeability.

Soils of the **Craven-Mattaponi-Lenoir-Coxville Series (VA035)** are very deep and range from well drained to poorly drained. Permeability ranges from moderately slow to slow. This soil series was formed in clayey, sandy to silty loam. Slopes range from 0 to 25 percent.

The **Portsmouth - Roanoke -Rains - Eunola - Levy - Kalmia Series** (**VA037**) are very deep, very poorly to moderately well drained soils. These soils are located on low stream or marine terraces and in marshes of the Atlantic Coastal Plain. These series are formed from fluvial and marine sediments. Permeability of these soil types ranges from very slow to rapid, depending on soil composition.

The **Pamunkey-Nanesmond-Bibb-Kinston-Nawney-Bohicket Series (VA038)** consists of mostly very deep, very poorly to very well drained, fine to coarse loamy soils that formed in fluvial or marine sediments. They are on low stream or marine terraces of the Coastal Plain. Slopes are dominantly low to 0 percent.

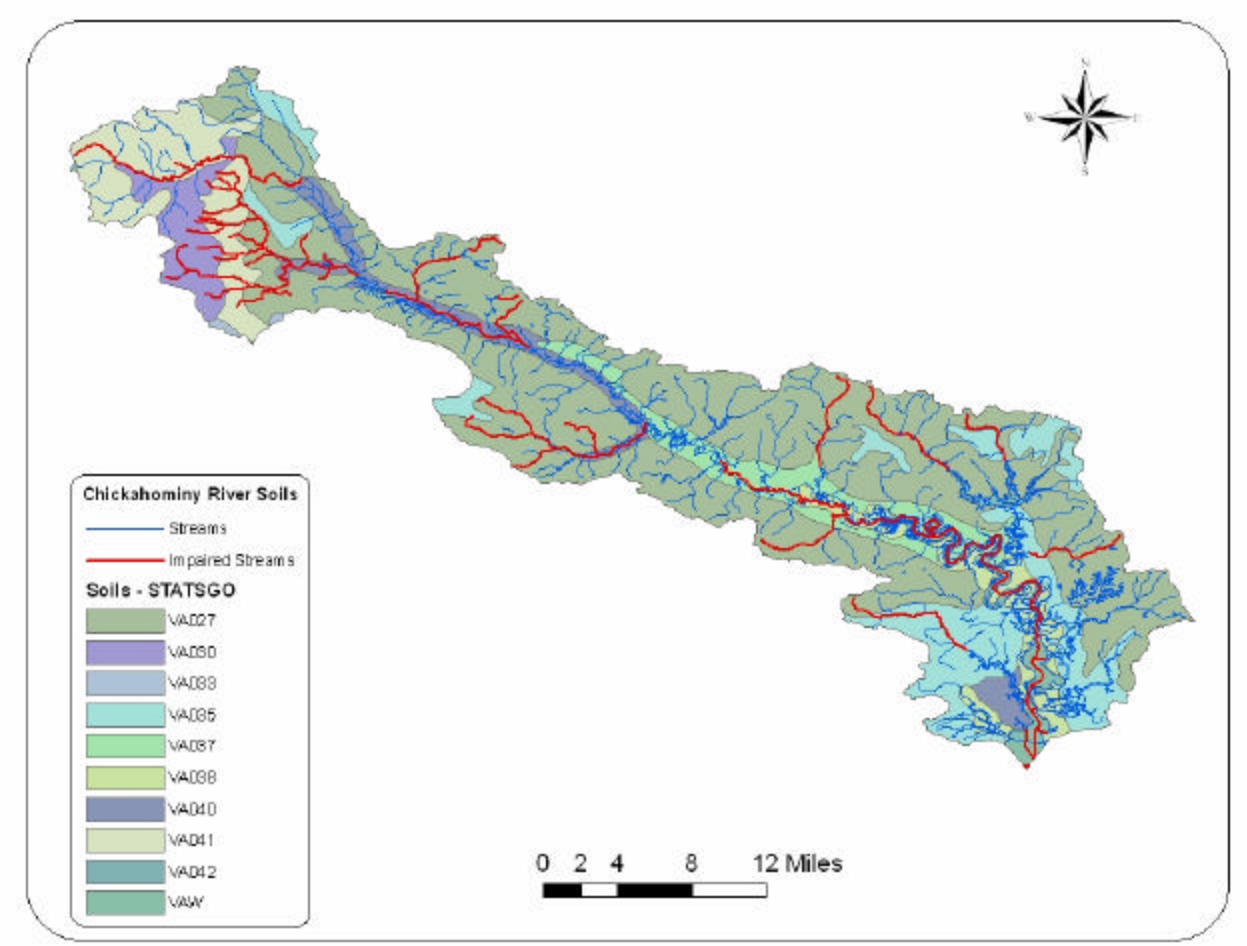
Soils of the **Bojac-Pamunkey-Munden-Angie-Augusta-Molena-Argent series (040**) are very deep and range from excessively drained to poorly drained conditions. Permeability is moderately rapid to slow. This series**,** located on stream terraces and uplands**,** is composed of loamy and sandy fluvial and marine Coastal Plain sediments.

Soils of the **Colfax-Bourne-Helena-Vance-Orange series (VA041**) consists are well drained to somewhat poorly drained. Permeability is moderate to slow. These soils formed from residuum

weathered from acid and basic rocks in the Piedmont. They are moderately deep to saprolite and very deep to bedrock.

The **Creedmoor-Partlow-Mayodan-Pinkston soils series** (**VA042**) are very deep, well drained to poorly drained soils. Permeability for this series ranges from moderately rapid to slow. These soils have formed either from Triassic material or in local colluvial and alluvial materials.

Figure 2. Soil Characteristics of the Chickahominy River Watershed.



Climate

The climate summary for Chickahominy River comes from a weather station located in Williamsburg, VA with a period of record from 8/1/1948 to 3/31/2004. The average annual maximum and minimum temperature (°F) at the weather station is 69.9 and 47.4 and the annual rainfall (inches) is 47.61 (Table 2) (Southeast Regional Climate Center, http://www.sercc.com/climateinfo/historical/historical_va.html).

Table 2. Climate summary for Williamsburg, Virginia (449151)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Average Max. Temperature (F)	48.9	52.1	60.5	71.1	78.3	85.1	88.5	87.0	81.3	71.4	62.4	52.4	69.9
Average Min.	27.9	29.9	36.4	45.2	54.5	62.5	67.3	66.2	60.2	48.4	39.3	31.3	47.4

Temperature (F)													
Average Total Precipitation (in.)	3.73	3.49	4.31	3.21	4.23	3.85	5.43	5.12	4.33	3.31	3.26	3.36	47.61

Land Use

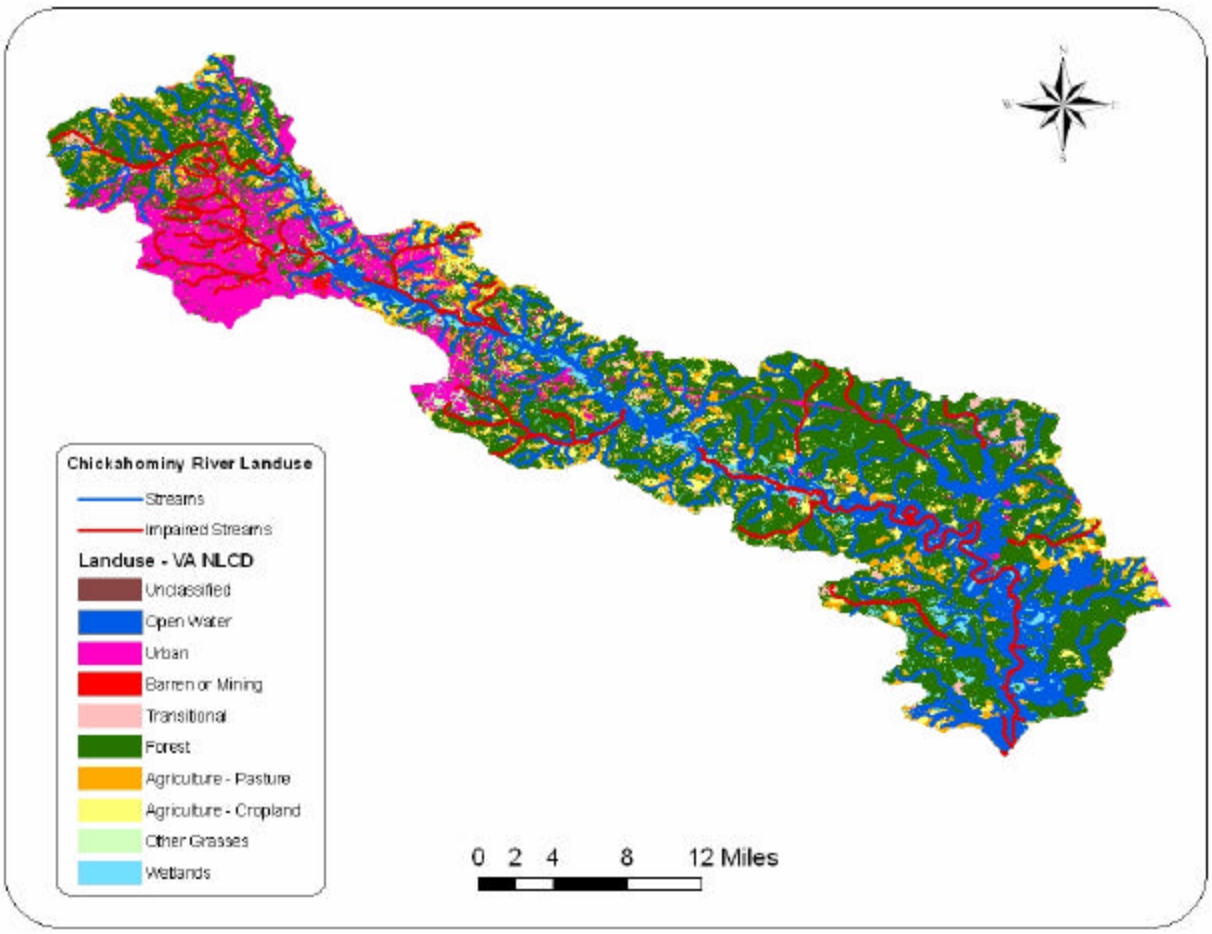
The Chickahominy River watershed extends approximately 85.9 miles upstream from its confluence with the James River to its headwaters near the Hylas, VA, and is about 10 miles wide. The watershed is approximately 300,203.9 acres in size and is predominately forested (55.0 percent). Agriculture encompasses 14.7 percent of the watershed, with 6.9 percent cropland and 7.8 percent pasture/hayland. Residential and industrial areas compose approximately 13.1percent of the land base. The remaining 17.1 percent of the watershed is comprised of 1.4 percent of transitional areas and grasses, and 15.7 percent wetlands and open water. Land use is described in Table 3.

A map of the distribution of land use in the watershed (Figure 3) shows that urban land use is concentrated near the headwaters, and wetlands / water land use is concentrated along the mainstem in the center and downstream portions to the mouth.

Table 3. Land Use in the Chickahominy River Watershed

Landuse	Count	Acres	Sq Miles	Percent of Total
Open Water	54284	12072.4816	18.8330713	4.02
Low Intensity Residential	106926	23779.79088	37.09647377	7.92
High Intensity Residential	1536	341.5984773	0.532893625	0.11
High Intensity Commercial/Industrial/Transportation	65321	14527.05347	22.66220342	4.84
Bare Rock/Sand/Clay	0	0	0	0.00
Quarries/Strip Mines/Gravel Pits	2574	572.4443233	0.893013144	0.19
Transitional	16375	3641.715538	5.681076239	1.21
Deciduous Forest	302658	67309.57809	105.0029418	22.42
Evergreen Forest	104658	23275.39937	36.30962302	7.75
Mixed Forest	335745	74667.95623	116.4820117	24.87
Pasture/Hay	105495	23461.54386	36.60000842	7.82
Row Crops	93181	20722.97377	32.32783908	6.90
Other Grasses (Urban/recreational; e.g. parks)	3142	698.7645936	1.090072766	0.23
Woody Wetlands	117501	26131.61633	40.76532147	8.70
Emergent Herbaceous Wetlands	40473	9000.98644	14.04153885	3.00
	Total:	300203.903	468.3180886	100.00

Figure 3. Land Use in the Chickahominy River Watershed



3. Description of Water Quality Problem/Impairment

The Chickahominy River was listed as impaired on Virginia's 1996 303(d) Total Maximum Daily Load Priority List Report, 1998 303(D) Total Maximum Daily Load Priority List and Report, 2002 303(d) Total Maximum Daily Load Priority List and Report and the 2004 305(b) / 303(d) Integrated Report (VADEQ, 1997, 1998, 2002 & 2004) due to violations of the State's water quality standard for dissolved oxygen.

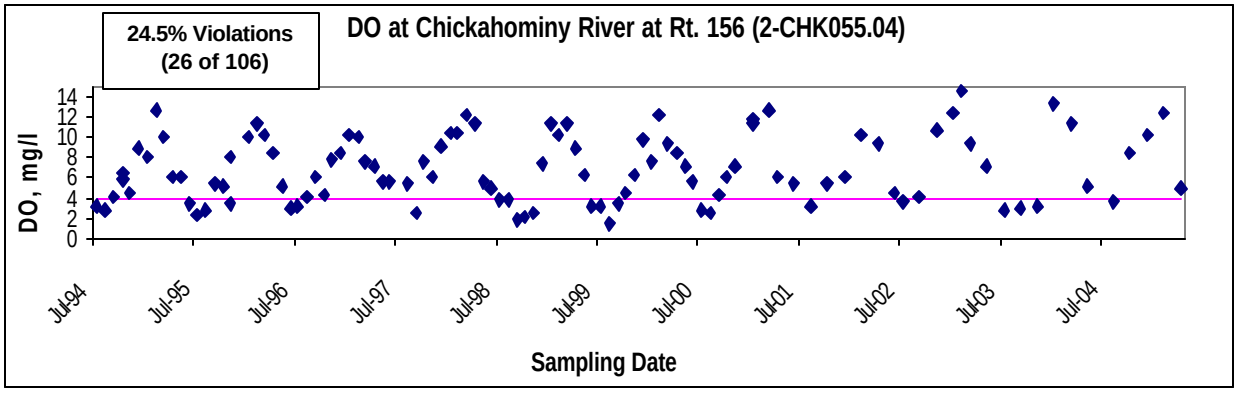
A total of 106 DO concentration data points, with 26 water quality standard violations (24.5%), have been taken by DEQ at station 2-CHK055.04 (see Figure 1) from July 19, 1994 through April 22, 2005 (Table 4).

Table 4. DO data collected by DEQ on Chickahominy River at Rt. 156.

				mg/l			
Station	**Date of First Sample**	**Date of Last Sample**	**Number of Samples**	**Average**	**Minimum**	**Maximum**	**Number of Violations**
2-CHK055.04	7/19/94	4/22/05	106	6.86	14.5	1.6	26

A time series graph of all data collected at station 2-CHK055.04 shows the DO concentrations ranging from 1.6 mg/l to 14.5 mg/l (Figure 4). The horizontal line at the DO = 4.0 mark represents the minimum water quality standard. The data points below the DO = 4.0 line illustrate violations of the water quality standard.

Figure 4. Time series of DO at Chickahominy River at Rt. 156, 2-CHK055.04.



3.1 Associated Mainstem DO

DEQ also monitored four associated mainstem stations during data collection for the low DO assessment of natural conditions or development of a TMDL. Associated station DO data are presented in Figures 5-8 below.

Figure 5. DO at Chickahominy River at Rt. 360, 2-CHK062.57.

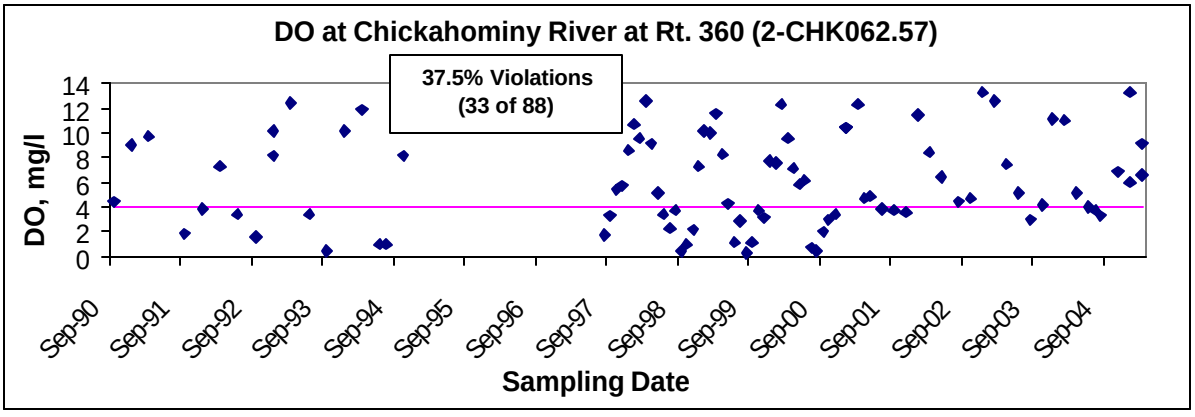


Figure 6. DO Concentrations at Chickahominy River at Rt. 625, 2-CHK076.59.

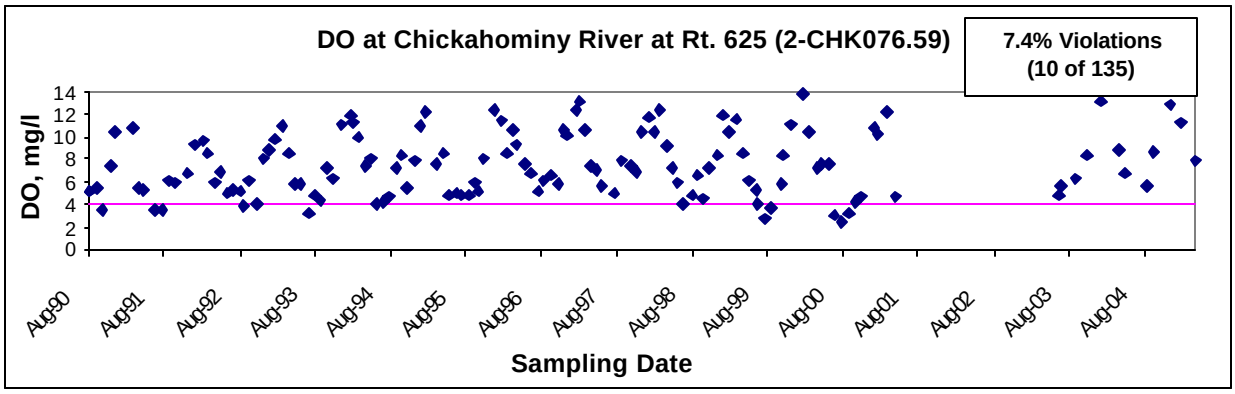


Figure 7. DO Concentrations at Chickahominy River at Rt. 106, 2-CHK042.22.

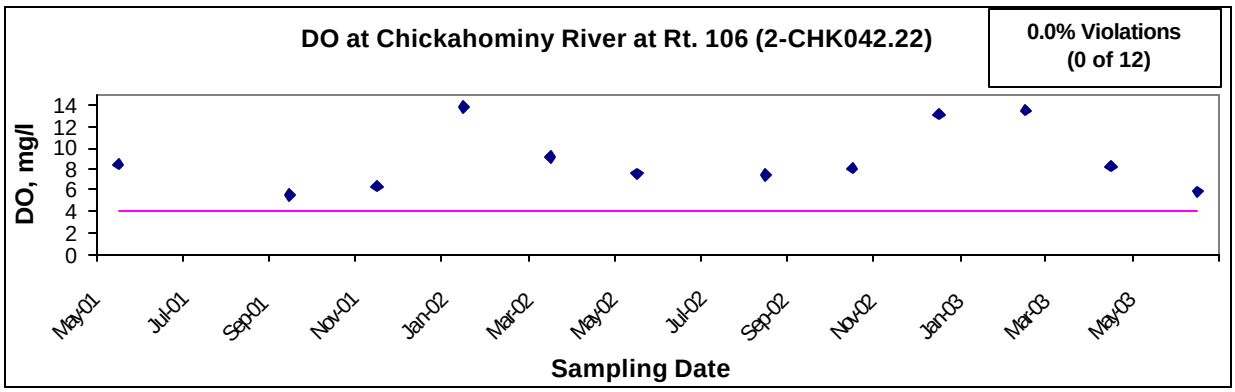
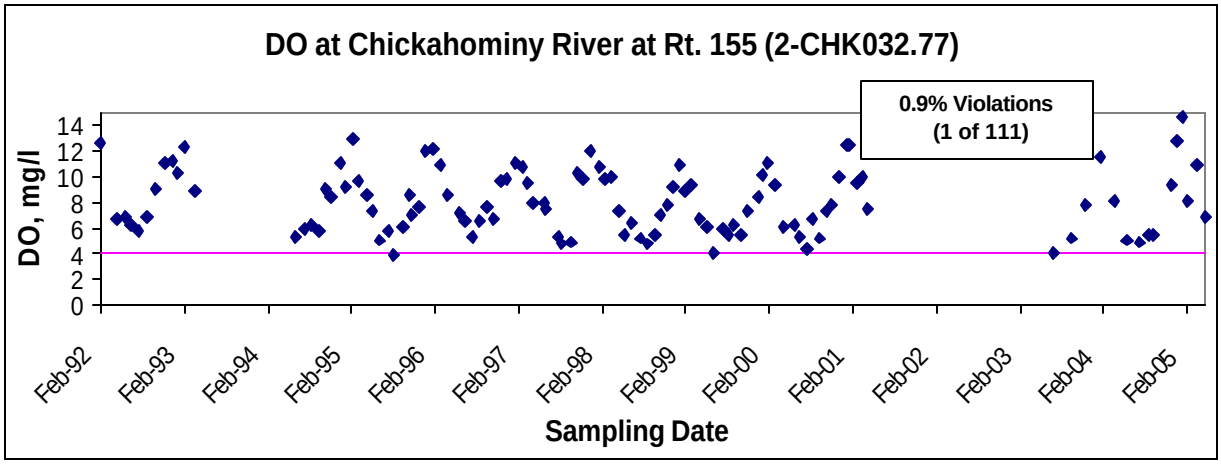


Figure 8. DO Concentrations at Chickahominy River at Rt. 155, 2-CHK032.77.



4. Water Quality Standard

According to Virginia Water Quality Standards (9 VAC 25-260-5), the term *"water quality standards means provisions of state or federal law which consist of a designated use or uses for the waters of the Commonwealth and water quality criteria for such waters based upon such uses. Water quality standards are to protect the public health or welfare, enhance the quality of water and serve the purposes of the State Water Control Law (§62.1-44.2 et seq. of the Code of Virginia) and the federal Clean Water Act (33 USC §1251 et seq.)."*

As stated above, Virginia water quality standards consist of a designated use or uses and a water quality criteria. These two parts of the applicable water quality standard are presented in the sections that follow.

4.1. Designated Uses

According to Virginia Water Quality Standards (9 VAC 25-260-10A), *"all state waters are designated for the following uses: recreational uses (e.g., swimming and boating); the propagation and growth of a balanced indigenous population of aquatic life, including game fish, which might be reasonably expected to inhabit them; wildlife; and the production of edible and marketable natural resources (e.g., fish and shellfish)."*

As stated above, Chickahominy River must support all designated uses and meet all applicable criteria.

4.2. Applicable Water Quality Criteria

The applicable water quality criteria for DO in the Chickahominy River watershed is an instantaneous minimum DO of 4.0 mg/l.

Table 5. Applicable water quality standards

Parameter	Minimum, mg/l	Maximum, mg/l
DO	4.0	na

If the waterbody exceeds the criterion listed above in more than 10.5 percent of samples, the waterbody is classified as impaired and natural conditions must be determined or a TMDL must be developed and implemented to bring the waterbody into compliance with the water quality criterion.

5. Assessment of Natural Conditions Affecting low DO - Process for determining if DO and pH impairments in free-flowing streams are due to natural conditions.

The level of dissolved oxygen in a water body is determined by a balance between oxygen-depleting processes (*e.g.*, decomposition and respiration) and oxygen-restoring processes (*e.g.*, aeration and photosynthesis). Certain natural conditions promote a situation where oxygen-restoring processes are not sufficient to overcome the oxygen- depleting processes. The level of pH in a water body is determined by a balance between organic acids produced by decay of vegetative material, and buffering capacity. Conditions in a stream that would typically be associated with naturally low DO and pH include slow-moving, ripple-less waters or wetlands

where the decay of organic matter produces organic acids. These situations can be compounded by anthropogenic activities that contribute excessive nutrients or readily available organic matter to these systems. The general approach to determine if DO and pH impairments in streams are due to natural conditions is to assess a series of water quality and hydrologic criteria to determine the likelihood of an anthropogenic source. A logical 4-step process for identifying natural conditions that result in low DO and/or pH levels and for determining the likelihood of anthropogenic impacts that will exacerbate the natural condition is described below.

Step 1. Determine slope and appearance.
Step 2. Determine nutrient levels.
Step 3. Determine degree of seasonal fluctuation (for DO only).
Step 4. Determine anthropogenic impacts.

The results from this methodology (or process or approach) will be used to determine if the stream should be re-classified as Class VII Swamp Waters. Each step is described in detail below.

Procedure for Natural Condition Assessment of low pH and low DO in Virginia Streams

Prepared by Virginia Department of Environmental Quality
October 2004

I. INTRODUCTION

Virginia's list of impaired waters currently shows many waters as not supporting the aquatic life use due to exceedances of pH and/or DO criteria that are designed to protect aquatic life in Class III waters. However, there is reason to believe that most of these streams or stream segments have been mis-classified and should more appropriately be classified as Class VII, Swamp Waters. This document presents a procedure for assessing if natural conditions are the cause of the low pH and/or low DO levels in a given stream or stream segment.

The level of dissolved oxygen (DO) in a water body is determined by a balance between oxygen-depleting processes (*e.g.*, decomposition and respiration) and oxygen-restoring processes (*e.g.*, aeration and photosynthesis). Certain natural conditions promote a situation where oxygen-restoring processes are not sufficient to overcome the oxygen-depleting processes. The level of acidity as registered by pH in a water body is determined by a balance between organic acids produced by decay of vegetative material, and buffering capacity.

Conditions in a stream that would typically be associated with naturally low DO and/or naturally low pH include slow-moving, ripple-less waters. In such waters, the decay of organic matter depletes DO at a faster rate than it can be replenished and produces organic acids (tannins, humic and fulvic substances). These situations can be compounded by anthropogenic activities that contribute excessive nutrients or readily available organic matter to these systems.

The general approach to determine if DO and pH impairments in streams are due to natural conditions is to assess a series of water quality and hydrologic criteria to determine the likelihood of an anthropogenic source. A logical 4-step process for identifying natural conditions that result in low DO and/or pH levels and for determining the likelihood of anthropogenic impacts that will exacerbate the natural condition is described below. DEQ staff is proposing to use this approach to implement State Water Control Law 9 VAC 25-260-55, Implementation Procedure for Dissolved Oxygen Criteria in Waters Naturally Low in Dissolved Oxygen.

Waters that are shown to have naturally low DO and pH levels will be re-classified as Class VII, Swamp Waters, with the associated pH criterion of 4.3 to 9.0 SU. An associated DO criterion is currently being developed from swamp water data. A TMDL is not needed for these waters. An assessment category of 4C will be assigned until the waterbody has been re-classified.

II. Natural Condition Assessment

Following a description of the watershed (including geology, soils, climate, and land use), a description of the DO and/or pH water quality problem (including a data summary, time series and monthly data distributions), and a description of the water quality criteria that were the basis for the impairment determination, the available information should be evaluated in four steps.

Step 1. Determine appearance and flow/slope.

Streams or stream segments that have naturally low DO (< 4 mg/L) and low pH (< 6 SU) are characterized by very low slopes and low velocity flows (flat water with low reaeration rates). Decaying vegetation in such swampy waters provides large inputs of plant material that consumes oxygen as it decays. The decaying vegetation in a swamp water also produces acids and decreases pH. Plant materials contain polyphenols such as tannin and lignin. Polyphenols and partially degraded polyphenols build up in the form of tannic acids, humic acids, and fulvic acids that are highly colored. The trees of swamps have higher polyphenolic content than the soft-stemmed vegetation of marshes. Swamp streams (blackwater) are therefore more highly colored and more acidic than marsh streams.

Appearance and flow velocity (or slope if flow velocity is not available) must be identified for each stream or stream segment to be assessed for natural conditions and potential re-classification as a Class VII swamp water. This can be done through maps, photos, field measurements or other appropriate means.

Step 2. Determine nutrient levels.

Excessive nutrients can cause a decrease in DO in relatively slow moving systems, where aeration is low. High nutrient levels are an indication of anthropogenic inputs of nitrogen, phosphorus, and possibly organic matter. Nutrient input can stimulate plant growth, and the resulting die-off and decay of excessive plankton or macrophytes can decrease DO levels.

USGS (1999) estimated national background nutrient concentrations in streams and groundwater from undeveloped areas. Average nitrate background concentrations are less than 0.6 mg/L for streams, average total nitrogen (TN) background concentrations are less than 1.0 mg/L, and average background concentrations of total phosphorus (TP) are less than 0.1 mg/L.

Nutrient levels must be documented for each stream or stream segment to be assessed for natural conditions and potential re-classification as a Class VII swamp water. Streams with average concentrations of nutrients greater than the national background concentrations should be further evaluated for potential impacts from anthropogenic sources.

Step 3. Determine degree of seasonal fluctuation (for DO only).

Anthropogenic impacts on DO will likely disrupt the typical seasonal fluctuation seen in the DO concentrations of wetland streams. Seasonal analyses should be conducted for each potential Class VII stream or stream segment to verify that DO is depressed in the summer months and recovers during the winter, as would be expected in natural systems. A weak seasonal pattern could indicate that human inputs from point or nonpoint sources are impacting the seasonal cycle.

Step 4. Determine anthropogenic impacts.

Every effort should be made to identify human impacts that could exacerbate the naturally low DO and/or pH. For example, point sources should be identified and DMR data analyzed to determine if there is any impact on the stream DO or pH concentrations. Land use analysis can also be a valuable tool for identifying potential human impacts.

Lastly, a discussion of acid rain impacts should be included for low pH waters. The format of this discussion can be based either on the process used for the recent Class VII classification of several streams in the Blackwater watershed of the Chowan Basin (letter from DEQ to EPA, 14 October 2003). An alternative is a prototype regional stream comparison developed for Fourmile Creek, White Oak Swamp, Matadequin Creek and Mechumps Creek (all east of the fall line). The example analysis under IV in this document, or the example report prepared for Fourmile Creek, illustrate this approach. For streams west of the fall line, a regional stream comparison for 2004 analyses encompasses Winticomack, Winterpock, and Chickahominy River s.

7Q10 Data Screen

If the data warrant it, a data screen should be performed to ensure that the impairment was identified based on valid data. All DO or pH data that violate water quality standards should be screened for flows less than the 7Q10. Data collected on days when flow was < 7Q10 should be eliminated from the data set and the violation rate recalculated accordingly. Only those waters with violation rates determined days with flows > or = 7Q10 flows should be classified as impaired.

In some cases, data were collected when flow was 0 cfs. If the 7Q10 is identified as 0 cfs as well, all data collected under 0 cfs flow would need to be considered in the water quality assessment. In those cases, the impairment should be classified as 4C, Impaired due to natural conditions, no TMDL needed. However, a reclassification to Class VII may not always be appropriate.

III. NATURAL CONDITION CONCLUSION MATRIX

The following decision process should be applied for determining whether low pH and/or low DO values are due to natural conditions and justify a reclassification of a stream or stream segment as Class VII, Swamp Water.

If velocity is low or if slope is low (<0.50%) AND
If wetlands are present along stream reach AND
If no point sources or only point sources with minimal impact on DO and pH AND
If nutrients are < typical background

- ❖ average (= assessment period mean) nitrate less than 0.6 mg/L
- ❖ average total nitrogen (TN) less than 1.0 mg/L, and
- ❖ average total phosphorus (TP) are less than 0.1 mg/L AND

For DO: If seasonal fluctuation is normal AND
For pH: If nearby streams without wetlands meet pH criteria OR if no correlation between in-stream pH and rain pH,

THEN determine as impaired due to natural condition
→ assess as category 4C in next assessment
→ initiate WQS reclassification to Class VII Swamp Water
→ get credit under consent decree

The analysis must state the extent of the natural condition based on the criteria outlined above. A map showing land use, point sources, water quality stations and, if necessary, the delineated segment to be classified as swamp water should be included.

In cases where not all of these criteria apply, a case by case argument must be made based on the specific conditions in the watershed.

5.1 Preliminary Data Screen for Low Flow 7Q10

The 7Q10 flow of a stream is the lowest streamflow for seven consecutive days that occurs on average once every ten years. The first step for low flow 7Q10 screening is to determine the most accurate 7Q10 available. The 7Q10 flows for the Chickahominy River DO station may be estimated by a drainage area comparison between 2-CHK055.04 and the drainage area and 7Q10 flow at the long-term gaging station Chickahominy River near Providence Forge, VA, (#02042500), located 19.7 miles downstream of 2-CHK055.04. The 7Q10 for Chickahominy River near Providence Forge was used with a drainage area ratio with the DO site, yielding a 7Q10 flow of 1.1cfs at 2-CHK055.04.

The DO Instantaneous Water Quality Standard applies **AT** 7Q10 flow, but **NOT** below 7Q10 flow (9 VAC 25-260-50 ***). Therefore in streams where the 7Q10 > 0.0 cfs, DO less than 4.0 mg/l taken at flows below 7Q10 are not water quality standard violations. However, in streams where the 7Q10 = 0.0 cfs, **ALL** DO data < 4.0 mg/l are standard violations, even if the flow = 0 cfs when the DO was taken.

At station 2-CHK055.04 on the Chickahominy River, flow was less than the 7Q10 of 1.1 cfs for two of the low DO exceedances, 2.57 mg/l on 9/9/1997 and 3.70 mg/l on 7/15/2002. Removing these two events from the violations yields a 22.6% violation rate.

5.2 Low slope, Swamps, Wetlands or Large Forested Areas

There were no discharge measurements made at the Rt. 156 bridge, 2-CHK055.04, the original 303(d) listing station, or at the Rt. 360 bridge at 2-CHK062.57. The hydrologic slope from the 90 ft. topographic contour at rivermile 65.22, located 2.65 mi upstream of Rt. 360, downstream to the 50 ft topographic contour at rivermile 52.66, located 2.38 miles below Rt. 156 is estimated at 0.06%, which is considered very low slope. The low slope in this 12.56 mile segment contributes no human impact.

Slope upstream of this segment, from just below the confluence of Stony Run at the 110 ft contour at rivermile 70.76, located 0.6 mi downstream of I-95, downstream to the 90 ft contour at rivermile 65.22, located 2.6 mi above Rt. 360, is estimated at 0.07%, similarly very low slope. The confluence of the Chickahominy River with Stony Run may be considered the upstream boundary of swampwater conditions.

Slope upstream of this segment, from just below the mill dam at Rt. 626 at the 150 ft contour at rivermile 74.75, downstream to the 110 ft contour at rivermile 70.76, located 0.6 mi below I-95, is estimated at 0.19%, which is still considered low slope. However numerous gravel and cobble riffles occur in this segment, which no longer has swampy characteristics upstream of the confluence with Stony Run.

The Chickahominy River from the 50 ft topographic contour at rivermile 52.66, located 2.38 miles below Rt. 156 downstream to the 30 ft topographic contour at rivermile 42.33, located 0.74 mi below the confluence with Toe Ink Swamp exhibits very low slope (0.04%). Just below Toe Ink Swamp, The Chickahominy River at Rt. 106 (2-CHK042.22) has zero percent DO violations. The confluence with Toe Ink Swamp may be considered the downstream boundary of a low DO swampwater condition.

Therefore, the extent of the swampwater segment determined from the upstream boundary of very low slope near Stony Run in Hanover County, downstream to the boundary of low DO observations just below the confluence with Toe Ink Swamp, has a very low slope estimated at 0.05% Decomposition of the large inputs of decaying vegetation from areas of forested land with swamps and heavy tree canopy throughout the watershed increase oxygen demand and lower DO as they decay. These are not considered anthropogenic impacts.

Visual inspections from bridges at Rts. 360, and 156 revealed large swamp areas with heavy tree canopy. Decomposition of vegetative matter from large swampy areas lowers DO as decay occurs. (Figures 9-10).

Figure 9. Chickahominy River at Rt. 360, 2-CHK062.57, west channel, upstream.

Figure 10. Chickahominy River at Rt. 156, 2-CHK055.04, upstream.

5.3 Instream Nutrients

The VADEQ collected nutrient data from station 2-CHK055.04 from July 1994 to March 2003 (Table 6). The average nutrient concentrations are at or below the USGS (1999) national background nutrient concentrations in streams from undeveloped areas levels of nitrate < 0.6 mg/l; TN (TKN + NO_3 + NO_2) < 1.0 mg/l; and TP < 0.1 mg/l. These low nutrient levels are not indicative of human impact.

Table 6. Instream Nutrients of Chickahominy River at Rt. 156 2-CHK055.04.

Parameter	Average Conc.	Number
Total Phosphorus	**0.088 mg/l**	(n=92)
Orthophosphorus	0.075 mg/l	(n=92)
Total Kjeldahl Nitrogen	0.615 mg/l	(n=92)
Ammonia as N	0.039 mg/l	(n=92)
Nitrate as N	**0.093 mg/l**	(n=92)
Nitrite as N	0.008 mg/l	(n=92)
TN (TKN + NO_3 + NO_2)	**0.716 mg/l**	(n=92)

The VADEQ also collected nutrient data from station 2-CHK062.57 from January 1990 to March 2006 (Table 7). The average nutrient concentrations are at or below the USGS (1999) national background nutrient concentrations in streams from undeveloped areas levels of nitrate < 0.6 mg/l; TN (TKN + NO_3 +

NO_2) < 1.0 mg/l; and TP < 0.1 mg/l. These low nutrient levels do not indicate significant human impact below the major urban land use area of the watershed.

Table 7. Instream Nutrients of Chickahominy River at Rt. 360 2-CHK062.57, below Upham Brook.

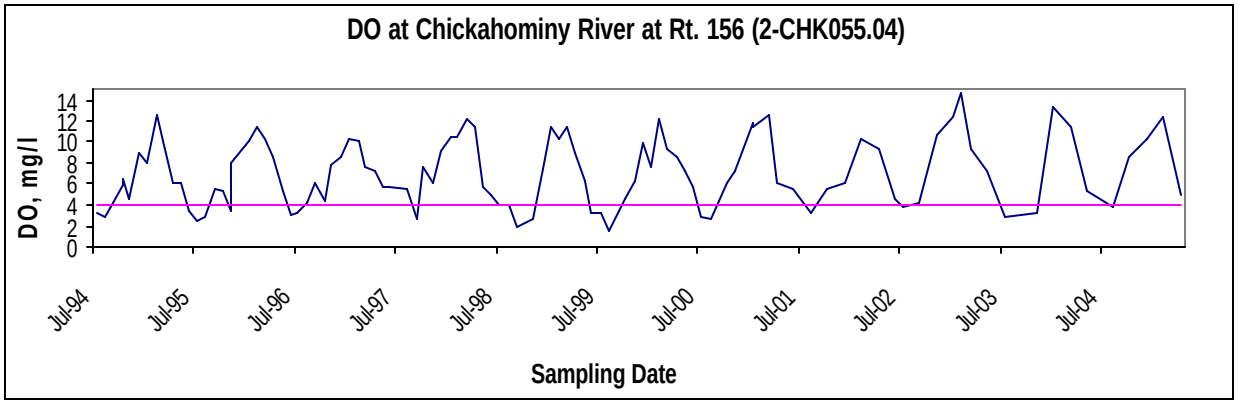
Parameter	Average Conc.	Number
Total Phosphorus	**0.096 mg/l**	(n=95)
Orthophosphorus	0.066 mg/l	(n=78)
Total Kjeldahl Nitrogen	0.722 mg/l	(n=78)
Ammonia as N	0.044 mg/l	(n=78)
Nitrate as N	**0.108 mg/l**	(n=78)
Nitrite as N	0.008 mg/l	(n=78)
TN (TKN + NO_3 + NO_2)	**0.837 mg/l**	(n=78)

These levels of nitrate, total nitrogen and total phosphorus (bolded in black) are at or below the USGS (1999) national background nutrient concentrations in streams from undeveloped areas levels of nitrate < 0.6 mg/l; TN (TKN + NO_3 + NO_2) < 1.0 mg/l; and TP < 0.1 mg/l.

5.4 Natural Seasonal DO Fluctuation

Chickahominy River exhibits natural seasonal DO fluctuation due to the inverse relationship between water temperature and DO. DO is high in the winter months while water temperatures are low, and low in the summer months when water temperatures are high. This is depicted in Figure 11.

Figure 11. Seasonal Variation in DO at Chickahominy River at Rt. 156, 1994– 2005.



5.5 Impact from Point Source Dischargers and Land Use

There are 73 permitted VPDES (7), VPG (2), VAR (34), VAG (26), and VPA (4) Point Source facilities in the Chickahominy River watershed. These are listed in Appendix B. Six VPDES permittees and four General permit single family homes have design flows and BOD5 or DO permit limits which could affect instream DO. The remaining VPDES permittee has a design flow but no BOD5 or DO limit. Four VPA permittees have no design flow allowed. Thirty-two industrial stormwater, two phase II MS4, five NMMM, and 16 ready-mix concrete stormwater permittees have neither design flows nor BOD5 / DO limits. These are not expected to significantly impact DO.

Of the ten permittees with design flows and BOD5 or DO permit limits, Tyson Foods Incorporated, VA0004031, with design flow of 1.4 MGD and maximum BOD5 of 8.0 mg/l, is located on an unnamed

tributary of the Chickahominy River 16.1 miles above station 2-CHK062.57. There are two large impoundments on the UT and on the Chickahominy River in this distance. A monitoring station at 2-CHK076.59, 2.1 miles below the Tyson Foods UT, has seven low DO violations in 143 data points (4.9%) since 1990. The Tyson Foods discharge is not expected to influence DO at station 2-CHK062.57. Tidewater Quarries Inc. – Springfield Quarry, VA0058041, with a design flow of 0.6 MGD and BOD5 limit of 8.0 mg/l, is located on the Chickahominy River 18.1 miles above station 2-CHK062.57. The station at 2-CHK076.59 also reflects insignificant DO impact below this facility. Travel Center of America Inc, VA0061972, with a design flow of 0.01MGD and BOD5 limit of 8.0 mg/l, is located on a UT to Lickinghole Creek 11.8 miles above station 2-CHK062.57. This facility only discharges during rainfall events, and with the small design flow is not expected to significantly affect DO at 2-CHK062.57. Richmond International Airport, VA0090301, with a design flow of 2.8 MGD and a BOD5 limit of 8.0 mg/l, discharges to the headwaters of White Oak Swamp 15.1 miles above monitoring station 2-CHK042.22, with zero DO violations in 12 data points. This facility discharges only during significant rain events, and is not expected to significantly impact DO in the Chickahominy River. Chickahominy WWTP, VA0088480, with a design flow of 0.405 MGD and a maximum BOD5 limit of 8.0 mg/l, discharges to an unnamed tributary of Rumley Marsh, a tributary of Jones Run and the Chickahominy River near Providence Forge, VA, 21.6 miles below station 2-CHK055.04, and below the swampwater segment in question. Hideaway STP, VA0080233, with a design flow of 0.02 MGD and a BOD5 limit of 45.0 mg/l, discharges to the tidal Chickahominy River more than 40 miles below station 2-CHK055.04, and has no impact on this assessment. The four single family home permittees, with design flows <0.001 MGD and BOD5 limits of 30.0 mg/l, are all located
in the tidal portion of the Chickahominy River, from 2.4 miles below Walkers Dam to just below Ferry Point and the Rt. 5 bridge near the confluence with the James River. These have no impact on the non-tidal low DO segment.

Residential and high use industrial areas compose approximately 13.1 percent of the land base, a significant portion of the watershed. However, most of the urban land use occurs in the Upham Brook watershed at the far left in Figure No. 3, which passes through a swampy area of significant size in its lower portion before entering the mainstem Chickahominy River. The swampy lower segment of Upham Brook removes significant anthropogenic influences such as nutrients, as shown by the nutrient average concentrations below the USGS background levels at station 2-CHK062.57 just below the Upham Brook mouth in Table 7. The watershed is predominately forested (55.0 percent), with 17.1 percent wetlands and open water. The land use was not considered to have significantly impacted the swampwater conditions of the mainstem Chickahominy River, given the nutrient concentrations below the USGS background levels just below where Upham Brook enters the mainstem.

6.0 CONCLUSION

The following decision process is proposed for determining whether low DO values are due to natural conditions:

If slope is low (<0.50) AND
If wetlands or large areas of forested land are present along stream reach AND
If no point sources or point sources with minimal impact on DO AND
If nutrients are < typical background
- ❖ average (= assessment period mean) nitrate less than 0.6 mg/L
- ❖ average total nitrogen (TN) less than 1.0 mg/L, and
- ❖ average total phosphorus (TP) are equal to or less than 0.1 mg/L AND

If nearby streams without wetlands meet DO criteria,

THEN determine as impaired due to natural condition
→ assess as category 4C in next assessment
→ initiate WQS reclassification to Class VII Swamp Water
→ get credit under consent decree

Two low DO exceedances were removed from the dataset because they occurred at flows below 7Q10, which resulted in a 22.6 percent violation rate at original listing station 2-CHK055.04.

The extent of the swampwater segment determined from the upstream boundary of very low slope near Stony Run in Hanover County, downstream to the boundary of low DO observations just below the confluence with Toe Ink Swamp, has a very low slope estimated at 0.05% Decomposition of the large inputs of decaying vegetation from areas of forested land with swamps and heavy tree canopy throughout the watershed increase oxygen demand and lower DO as they decay. These are not considered anthropogenic impacts.

The Chickahominy River exhibits low nutrient concentrations below national background levels in streams from undeveloped areas, which are not indicative of human impact.

The Chickahominy River exhibits natural seasonal DO fluctuation due to the inverse relationship between water temperature and DO.

A total of 73 facilities are permitted to discharge to the Chickahominy River and its tributaries. However, of these, only three VPDES permittees are located upstream of the proposed swampwater segment, and have design flows and BOD5 or DO permit limits. The vast majority (70) are either located downstream of the river segment assessed here, or are stormwater permittees without flow or DO permit limits that only discharge during significant rain events. Tyson Foods Incorporated, VA0004031, with design flow of 1.4 MGD and maximum BOD5 of 8.0 mg/l, is located on an unnamed tributary of the Chickahominy River 16.1 miles above the upper listing station, 2-CHK062.57. Tidewater Quarries Inc. – Springfield Quarry, VA0058041, with a design flow of 0.6 MGD and BOD5 limit of 8.0 mg/l, is located on the Chickahominy River 18.1 miles above the upper listing station. There is a monitoring station at 2-CHK076.59, located 3 to 5 miles below these facilities. It has only seven low DO violations in 143 data points (4.9%) since 1990. Therefore the Tyson Foods and Tidewater Quarries Inc. discharges are not expected to influence DO at the upper swampy listing station 16 to 18 miles downstream. Travel Center of America Inc, VA0061972, with a design flow of 0.01MGD and BOD5 limit of 8.0 mg/l, is located on a UT to Lickinghole Creek 11.8 miles above station 2-CHK062.57. This facility only discharges during rainfall events, and with the small design flow is not expected to significantly affect DO at 2-CHK062.57.

Residential and high use industrial areas compose approximately 13.1 percent of the land base, a significant portion of the watershed. However, most of the urban land use occurs in the Upham Brook watershed at the far left in Figure No. 3, which passes through a swampy area of significant size in its lower portion before entering the mainstem Chickahominy River. There is a long-term station on Upham Brook, 2-UPM003.53 at Rt. 1, which has zero violations in 101 visits back to 1990. The swampy lower segment of Upham Brook below Rt. 1 has three stations with a combined one of 18 DO violations (5.6%). This segment also removes significant anthropogenic influences such as nutrients, as shown by the nutrient average concentrations below USGS background levels at station 2-CHK062.57 (Table 7) just below the Upham Brook mouth. The watershed is predominately forested (55.0 percent), with 17.1 percent wetlands and open water. The land use was not considered to have significantly impacted the swampwater conditions of the mainstem Chickahominy River, given the nutrient concentrations below the USGS background levels just below where Upham Brook enters the mainstem.

Based on the above information, a change in the water quality standards classification to Class VII Swampwater due to natural conditions, rather than a TMDL, is indicated for mainstem Chickahominy River from its confluence with Stony Run at rivermile 71.03 downstream to the confluence with Toe Ink Swamp at rivermile 43.07, a total of 28.0 rivermiles. If there is a 305(b)/303(d) assessment prior to the reclassification, Chickahominy River will be assessed as Category 4C, Impaired due to natural condition, no TMDL needed.

7.0. Public Participation

DEQ performed the assessment of the Chickahominy River low DO natural condition in lieu of a TMDL. Therefore neither a TMDL Technical Advisory Committee (TAC) meeting nor a public meeting was involved. Public participation will occur during the next water quality standards triennial review process.

8. References

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http://www.dnr.state.sc.us/climate/sercc/products/historical/historical_va.html (Accessed 12/18/02)

USGS (United States Geological Survey), National Background Nutrient Concentrations in Streams from Undeveloped Areas. 1999.

VADEQ (Virginia Department of Environmental Quality), Virginia Water Quality Assessment 1998. Virginia. 1998.

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Appendix A

Glossary

GLOSSARY

Note: All entries in italics are taken from USEPA (1998). All non-italicized entries are taken from MapTech (2002).

303(d). A section of the Clean Water Act of 1972 requiring states to identify and list water bodies that do not meet the states' water quality standards.

7Q10. The lowest streamflow for seven consecutive days that occurs on average once every ten years.

Ambient water quality. *Natural concentration of water quality constituents prior to mixing of either point or nonpoint source load of contaminants. Reference ambient concentration is used to indicate the concentration of a chemical that will not cause adverse impact on human health.*

Anthropogenic. *Pertains to the [environmental] influence of human activities.*

Background levels. *Levels representing the chemical, physical, and Bacterial conditions that would result from natural geomorphological processes such as weathering or dissolution.*

Best management practices (BMPs). *Methods, measures, or practices determined to be reasonable and cost-effective means for a landowner to meet certain, generally nonpoint source, pollution control needs. BMPs include structural and nonstructural controls and operation and maintenance procedures.*

Clean Water Act (CWA). *The Clean Water Act (formerly referred to as the Federal Water Pollution Control Act or Federal Water Pollution Control Act Amendments of 1972), Public Law 92-500, as amended by Public Law 96-483 and Public Law 97-117, 33 U.S.C. 1251 et seq. The Clean Water Act (CWA) contains a number of provisions to restore and maintain the quality of the nation's water resources. One of these provisions is section 303(d), which establishes the TMDL program.*

Concentration. *Amount of a substance or material in a given unit volume of solution; usually measured in milligrams per liter (mg/L) or parts per million (ppm).*

Confluence. The point at which a river and its tributary flow together.

Contamination. *The act of polluting or making impure; any indication of chemical, sediment, or Bacterial impurities.*

Designated uses. *Those uses specified in water quality standards for each waterbody or segment whether or not they are being attained.*

Dilution. *The addition of some quantity of less-concentrated liquid (water) that results in a decrease in the original concentration.*

Direct runoff. *Water that flows over the ground surface or through the ground directly into streams, rivers, and lakes.*

Discharge. *Flow of surface water in a stream or canal, or the outflow of groundwater from a flowing artesian well, ditch, or spring. Can also apply to discharge of liquid effluent from a facility or to chemical emissions into the air through designated venting mechanisms.*

Discharge permits (under VPDES). *A permit issued by the U.S. EPA or a state regulatory agency that sets specific limits on the type and amount of pollutants that a municipality or industry can discharge to a receiving water; it also includes a compliance schedule for achieving those limits. The permit process was established under the National Pollutant Discharge Elimination System, under provisions of the Federal Clean Water Act.*

Domestic wastewater. *Also called sanitary wastewater, consists of wastewater discharged from residences and from commercial, institutional, and similar facilities.*

Drainage basin. *A part of a land area enclosed by a topographic divide from which direct surface runoff from precipitation normally drains by gravity into a receiving water. Also referred to as a watershed, river basin, or hydrologic unit.*

Effluent. *Municipal sewage or industrial liquid waste (untreated, partially treated, or completely treated) that flows out of a treatment plant, septic system, pipe, etc.*

Effluent limitation. *Restrictions established by a state or EPA on quantities, rates, and concentrations in pollutant discharges.*

Existing use. *Use actually attained in the waterbody on or after November 28, 1975, whether or not it is included in the water quality standards (40 CFR 131.3).*

GIS. Geographic Information System. A system of hardware, software, data, people, organizations and institutional arrangements for collecting, storing, analyzing and disseminating information about areas of the earth. (Dueker and Kjerne, 1989)

Hydrologic cycle. *The circuit of water movement from the atmosphere to the earth and its return to the atmosphere through various stages or processes, such as precipitation, interception, runoff, infiltration, storage, evaporation, and transpiration.*

Hydrology. *The study of the distribution, properties, and effects of water on the earths surface, in the soil and underlying rocks, and in the atmosphere.*

In situ. *In place; in situ measurements consist of measurements of components or processes in a full-scale system or a field, rather than in a laboratory.*

Margin of safety (MOS). *A required component of the TMDL that accounts for the uncertainty about the relationship between the pollutant loads and the quality of the*

receiving waterbody (CWA section 303(d)(1)(C)). The MOS is normally incorporated into the conservative assumptions used to develop TMDLs (generally within the calculations or models) and approved by EPA either individually or in state/EPA agreements. If the MOS needs to be larger than that which is allowed through the conservative assumptions, additional MOS can be added as a separate component of the TMDL (in this case, quantitatively, a TMDL = LC = WLA + LA + MOS).

Mean. The sum of the values in a data set divided by the number of values in the data set.

MGD. Million gallons per day. A unit of water flow, whether discharge or withdraw.

Monitoring. *Periodic or continuous surveillance or testing to determine the level of compliance with statutory requirements and/or pollutant levels in various media or in humans, plants, and animals.*

Narrative criteria. *Nonquantitative guidelines that describe the desired water quality goals.*

National Pollutant Discharge Elimination System (NPDES). *The national program for issuing, modifying, revoking and re-issuing, terminating, monitoring, and enforcing permits, and imposing and enforcing pretreatment requirements, under sections 307, 402, 318, and 405 of the Clean Water Act.*

Natural waters. *Flowing water within a physical system that has developed without human intervention, in which natural processes continue to take place.*

Non-point source. *Pollution that originates from multiple sources over a relatively large area. Nonpoint sources can be divided into source activities related to either land or water use including failing septic tanks, improper animal-keeping practices, forest practices, and urban and rural runoff.*

Numeric targets. *A measurable value determined for the pollutant of concern, which, if achieved, is expected to result in the attainment of water quality standards in the listed waterbody.*

Organic matter. *The organic fraction that includes plant and animal residue at various stages of decomposition, cells and tissues of soil organisms, and substances synthesized by the soil population. Commonly determined as the amount of organic material contained in a soil or water sample.*

Peak runoff. *The highest value of the stage or discharge attained by a flood event; also referred to as flood peak or peak discharge.*

Permit. *An authorization, license, or equivalent control document issued by EPA or an approved federal, state, or local agency to implement the requirements of an environmental regulation; e.g., a permit to operate a wastewater treatment plant or to operate a facility that may generate harmful emissions.*

Point source. *Pollutant loads discharged at a specific location from pipes, outfalls, and conveyance channels from either municipal wastewater treatment plants or industrial waste treatment facilities. Point sources can also include pollutant loads contributed by tributaries to the main receiving water stream or river.*

Pollutant. *Dredged spoil, solid waste, incinerator residue, sewage, garbage, sewage sludge, munitions, chemical wastes, Bacterial materials, radioactive materials, heat, wrecked or discarded equipment, rock, sand, cellar dirt, and industrial, municipal, and agricultural waste discharged into water. (CWA section 502(6)).*

Pollution. *Generally, the presence of matter or energy whose nature, location, or quantity produces undesired environmental effects. Under the Clean Water Act, for example, the term is defined as the man-made or man-induced alteration of the physical, Bacterial, chemical, and radiological integrity of water.*

Public comment period. *The time allowed for the public to express its views and concerns regarding action by EPA or states (e.g., a Federal Register notice of a proposed rule-making, a public notice of a draft permit, or a Notice of Intent to Deny).*

Raw sewage. *Untreated municipal sewage.*

Receiving waters. *Creeks, streams, rivers, lakes, estuaries, ground-water formations, or other bodies of water into which surface water and/or treated or untreated waste are discharged, either naturally or in man-made systems.*

Restoration. *Return of an ecosystem to a close approximation of its presumed condition prior to disturbance.*

Riparian areas. *Areas bordering streams, lakes, rivers, and other watercourses. These areas have high water tables and support plants that require saturated soils during all or part of the year. Riparian areas include both wetland and upland zones.*

Riparian zone. *The border or banks of a stream. Although this term is sometimes used interchangeably with floodplain, the riparian zone is generally regarded as relatively narrow compared to a floodplain. The duration of flooding is generally much shorter, and the timing less predictable, in a riparian zone than in a river floodplain.*

Runoff. *That part of precipitation, snowmelt, or irrigation water that runs off the land into streams or other surface water. It can carry pollutants from the air and land into receiving waters.*

Slope. *The degree of inclination to the horizontal. Usually expressed as a ratio, such as 1:25 or 1 on 25, indicating one unit vertical rise in 25 units of horizontal distance, or in a decimal fraction (0.04), degrees (2 degrees 18 minutes), or percent (4 percent).*

Stakeholder. Any person with a vested interest in assessment of natural condition or TMDL development.

Standard. In reference to water quality (e.g. pH 6 – 9 SU limit).

Storm runoff. *Storm water runoff, snowmelt runoff, and surface runoff and drainage; rainfall that does not evaporate or infiltrate the ground because of impervious land surfaces or a soil infiltration rate lower than rainfall intensity, but instead flows onto adjacent land or into waterbodies or is routed into a drain or sewer system.*

Streamflow. *Discharge that occurs in a natural channel. Although the term "discharge" can be applied to the flow of a canal, the word "streamflow" uniquely describes the discharge in a surface stream course. The term "streamflow" is more general than "runoff" since streamflow may be applied to discharge whether or not it is affected by diversion or regulation.*

Stream restoration. *Various techniques used to replicate the hydrological, morphological, and ecological features that have been lost in a stream because of urbanization, farming, or other disturbance.*

Surface area. *The area of the surface of a waterbody; best measured by planimetry or the use of a geographic information system.*

Surface runoff. *Precipitation, snowmelt, or irrigation water in excess of what can infiltrate the soil surface and be stored in small surface depressions; a major transporter of nonpoint source pollutants.*

Surface water. *All water naturally open to the atmosphere (rivers, lakes, reservoirs, ponds, streams, impoundments, seas, estuaries, etc.) and all springs, wells, or other collectors directly influenced by surface water.*

Topography. *The physical features of a geographic surface area including relative elevations and the positions of natural and man-made features.*

Total Maximum Daily Load (TMDL). *The sum of the individual wasteload allocations (WLAs) for point sources, load allocations (LAs) for nonpoint sources and natural background, plus a margin of safety (MOS). TMDLs can be expressed in terms of mass per time, toxicity, or other appropriate measures that relate to a state's water quality standard.*

Tributary. *A lower order-stream compared to a receiving waterbody. "Tributary to" indicates the largest stream into which the reported stream or tributary flows.*

Variance. A measure of the variability of a data set. The sum of the squared deviations (observation – mean) divided by (number of observations) – 1.

DCR. Department of Conservation and Recreation.

DEQ. Virginia Department of Environmental Quality.

VDH. Virginia Department of Health.

Wastewater. *Usually refers to effluent from a sewage treatment plant. See also* ***Domestic wastewater****.*

Wastewater treatment. *Chemical, Bacterial, and mechanical procedures applied to an industrial or municipal discharge or to any other sources of contaminated water to remove, reduce, or neutralize contaminants.*

Water quality. *The Bacterial, chemical, and physical conditions of a waterbody. It is a measure of a waterbody's ability to support beneficial uses.*

Water quality criteria. *Levels of water quality expected to render a body of water suitable for its designated use, composed of numeric and narrative criteria. Numeric criteria are scientifically derived ambient concentrations developed by EPA or states for various pollutants of concern to protect human health and aquatic life. Narrative criteria are statements that describe the desired water quality goal. Criteria are based on specific levels of pollutants that would make the water harmful if used for drinking, swimming, farming, fish production, or industrial processes.*

Water quality standard. *Law or regulation that consists of the beneficial designated use or uses of a waterbody, the numeric and narrative water quality criteria that are necessary to protect the use or uses of that particular waterbody, and an antidegradation statement.*

Watershed. *A drainage area or basin in which all land and water areas drain or flow toward a central collector such as a stream, river, or lake at a lower elevation.*

Appendix B

APPENDIX B. VPDES, VPG, VAR, VAG, and VPA Point Source Facilities in the Chickahominy River Watershed

APPENDIX B. VPDES, VPG, VAR, VAG, and VPA Point Source Facilities in the Chickahominy River Watershed

Receiving Stream	Facility Name	Permit No	Type	Design Flow, MGD	Permitted Max BOD5, mg/l
Chickahominy River U.T.	Tyson Foods Incorporated - Glen Allen	VA0004031	Ind Major	1.4	8.0
Chickahominy River	Tidewater Quarries Inc - Springfield Quarry	VA0058041	Ind minor	0.6	8.0
UT to Lickinghole Creek	Travel Center of America Incorporated	VA0061972	Ind minor	0.01	8.0
White Oak Swamp	Richmond International Airport	VA0090301	Ind minor	2.8	8.0
UT to Rumley Marsh	Chickahominy WWTP	VA0088480	Mun minor	0.405	8.0
Chickahominy River	Hideaway STP	VA0080233	Mun minor	0.02	45.0
Morris Creek	Mt Zion Rustic WTP	VA0085936	Mun minor	0.03	None
Chickahominy River/UT	Mount Sterling Farm	VPG140008	CAFO	0	None
Stony Run	White Oak Farm	VPG140056	CAFO	0	None
Xtrib to Chickahominy	INGENCO - Charles City Plant	VAG250093	cooling water	0	None
Chickahominy River	Graves Landing	VAG404198	Single Family Home	0.001	30.0
Chickahominy River	Gaertner William L and Jo C Residence	VAG404152	Single Family Home	0.001	30.0
Chickahominy River	Ripley Robert F and Catherine J Residence	VAG404144	Single Family Home	0.001	30.0
Chickahominy River	Clark Samuel and Kimberly Residence	VAG403039	Single Family Home	0.001	30.0
Licking Hole Creek	Dispersion Specialties Incorporated	VAR050580	Ind Stormwater	NL	NA
East Johns Branch	CSX Transportation Inc - Bryan Park Terminal	VAR051056	Ind Stormwater	NL	NA
Upham Brook	Cadmus Specialty Publications	VAR050694	Ind Stormwater	NL	NA
Chickahominy, UT	Airgas Carbonic Dry Ice - Hanover	VAR051259	Ind Stormwater	NL	NA
Thorpe Branch	Johns Manville	VAR051167	Ind Stormwater	NL	NA
Rocky Branch	Hankins and Johann Incorporated	VAR051060	Ind Stormwater	NL	NA
Rocky Branch	Taylor and Sledd Inc	VAR051054	Ind Stormwater	NL	NA
Lickinghole Creek	Giant Resource Recovery Inc	VAR050612	Ind Stormwater	NL	NA
Lickinghole Creek	Southern Concrete Products Richmond Pipe Plant	VAR050637	Ind Stormwater	NL	NA
Chickahominy River, UT	Als Auto Parts Ltd	VAR050681	Ind Stormwater	NL	NA
UT to Lickinghole Creek	B C Wood Products Incorporated	VAR051204	Ind Stormwater	NL	NA
Lickinghole Creek	Xenon Company Inc	VAR050883	Ind Stormwater	NL	NA
Chick/Rooty Br/Allen Br	Henrico Co DPU Springfield Rd Waste Management	VAR051025	Ind Stormwater	NL	NA
Chickahominy	Cascades Sonoco	VAR051257	Ind Stormwater	NL	NA
Lickinghole Creek	Chemtreat Incorporated - Ashland	VAR050664	Ind Stormwater	NL	NA
UT to Horse Swamp Cr	Pine Camp Landfill	VAR051381	Ind Stormwater	NL	NA
Chickahominy River, UT	Auditorium Auto Parts Incorporated	VAR050678	Ind Stormwater	NL	NA
Possum Run	Charles City Forest Products Incorporated	VAR051021	Ind Stormwater	NL	NA
Chickohominy River	Bruce Auto Parts	VAR050576	Ind Stormwater	NL	NA
Chickahominy- UT	Lacy Auto Parts Incorporated - Charles City	VAR051250	Ind Stormwater	NL	NA
White Oak Swamp Cr	Standex Engraving LLC	VAR051142	Ind Stormwater	NL	NA
UT to Chickahominy R	Ennis Paint Incorporated	VAR051550	Ind Stormwater	NL	NA
White Oak Swamp Cr	Portugee Road Plant	VAR051024	Ind Stormwater	NL	NA
UT Chickahominy R	Federal Express Corp RICRT	VAR051169	Ind Stormwater	NL	NA
Cornelius Creek	Vanguard Plastics Incorporated	VAR051636	Ind Stormwater	NL	NA
White Oak Creek	Stone Container Corporation - South Plant	VAR050570	Ind Stormwater	NL	NA
Chickahominy River	Dean Foods Company - Sandston	VAR050595	Ind Stormwater	NL	NA
UT to White Oak Saw Cr	Inline Technologies Richmond	VAR050573	Ind Stormwater	NL	NA

UT to White Oak Saw	Saint Laurent Paperboard Inc aka Smurfit Stone	VAR050874	Ind Stormwater	NL	NA
UT White Oak Swamp	Stone Container Corporation - North Plant	VAR050565	Ind Stormwater	NL	NA
Possum Run	Tire Recyclers Incorporated	VAR051160	Ind Stormwater	NL	NA
Bradley Run	Waste Management Charles City Landfill	VAR050648	Ind Stormwater	NL	NA
Chickahominy River	Hanover Co. MS4	VAR040012	MS4	NL	NA
Lickinghole Cr	Ashland Town MS4	VAR040011	MS4	NL	NA
UT to Boar Sw Cr	Brett Aggregates Incorporated - Portable 51290	VAG844048	NMMM	NL	NA
Colby Swamp	Massie Corporation MRA	VAG840164	NMMM	NL	NA
Tomahund Creek UT	Branscome Incorporated - Charles City Concrete	VAG844037	NMMM	NL	NA
Tomahund Creek UT	Tidewater Quarries Incorporated - Riverside Farm	VAG844026	NMMM	NL	NA
UT to James River	Tidewater Quarries Incorporated - Riverside Farm	VAG840135	NMMM	NL	NA
Chickahominy River	TCS Materials - Mechanicsville	VAG114005	Ready-mix	NL	NA
UT Chickahominy	TCS Materials - Mechanicsville	VAG110174	Ready-mix	NL	NA
UT Stony Creek	Roxbury Ready Mix Ashland Plant	VAG110216	Ready-mix	NL	NA
UT Lickinghole Creek	Titan America LLC - Ashland Ready Mix Plant	VAG110194	Ready-mix	NL	NA
UT Jordan Branch	Ready Mixed Concrete Company - Sacrete Road	VAG110201	Ready-mix	NL	NA
UT to White Oak Sw Cr	S B Cox Incorporated - Portugee Road	VAG110104	Ready-mix	NL	NA
UT to White Oak Sw Cr	S B Cox Incorporated - Portugee Road	VAG114033	Ready-mix	NL	NA
UT to White Oak Sw Cr	Mechanicsville Concrete Inc - Portugee Rd	VAG110160	Ready-mix	NL	NA
White Oak Swamp	Powhatan Ready Mix - Chesterfield Plant	VAG114007	Ready-mix	NL	NA
White Oak Swamp Cr	S B Cox Incorporated - Portugee Road	VAG110104	Ready-mix	NL	NA
White Oak Creek	S B Cox Incorporated - Portugee Road	VAG114033	Ready-mix	NL	NA
Chickahominy	Roxbury Ready Mix Incorporated	VAG114037	Ready-mix	NL	NA
UT Chickahominy	Roxbury Ready Mix Incorporated	VAG110198	Ready-mix	NL	NA
Chickahominy River	TCS Materials - Mechanicsville	VAG114005	Ready-mix	NL	NA
UT to Chickahominy R	TCS Materials - Providence Forge Plant	VAG114038	Ready-mix	NL	NA
UT Chickahominy R	TCS Materials - Providence Forge Plant	VAG110173	Ready-mix	NL	NA
UT Chickahominy	Creighton Rd Batch Plant	VPA00518	Ind minor	0	None
UT Rumley Marsh	Colonial Downs Racetrack	VPA00572	Mun minor	0	None
Chickahominy River	Roxbury Industrial Park	VPA00524	Mun Minor	0	None
Big Swamp	Golf Club at Brickshire	VPA00571	Mun Minor	0	None